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Deaths and Entanglements of Humpback Whales, *Megaptera novaeangliae*, in the Main Hawaiian Islands, 1972–1996[1]

L. MAZZUCA,[2] S. ATKINSON,[2,4] AND E. NITTA[3]

ABSTRACT: Reports of humpback whales, *Megaptera novaeangliae,* that either died or were entangled in Hawaiian waters from 1972 through October 1996 were analyzed to determine age class (estimated from body length and/or notes), location, annual frequency, and seasonal distribution of occurrence. Using reports collected from the National Marine Fisheries Service Pacific Area Office and published news reports, 26 whales were identified and their records analyzed. Deaths and entanglements were predominantly of calves of the year. Greatest incidence of deaths and entanglements occurred off the islands of Hawai'i, Maui, and O'ahu during the month of February. Of the 26 reported cases, 19 animals were confirmed dead. In the majority of the cases cause of death was unknown. However, shark attacks appear to be a secondary cause of death subsequent to entanglement, perinatal death, calf abandonment, illness, or unknown causes. The annual frequency of occurrence over the 25-yr period indicates an increasing trend of entanglement in natural fiber and synthetic lines since 1992 and a three-fold increase in death and entanglement occurrences related to human activity in 1996.

SINCE THE EARLY 1970s, with the passage of the Marine Mammal Protection Act and the Endangered Species Act in 1973, data have been collected systematically from live strandings, deaths, and entanglements of marine mammals. The information collected over the last two decades can be used to elucidate patterns of age, location, annual frequency, and seasonal distribution of many marine mammal species. For example, in Hawai'i, this information may provide insight into the factors affecting the North Pacific humpback whale population in one of its breeding grounds.

Throughout the world humpback whales migrate annually from high-latitude, cold-water feeding grounds to tropical waters for breeding and calving (Mackintosh 1942, Chittleborough 1965, Dawbin 1966). The waters surrounding the Hawaiian Islands provide one of the major wintering grounds for humpback whales in the North Pacific (Dawbin 1966, Herman and Antinoja 1977, Wolman and Jurasz 1977, Rice and Wolman 1978). Favoring waters of less than 100 fathoms (183 m) around the main Hawaiian Islands, the highest densities of humpback whales occur in the shallow-water, interisland channels of the four-island region (Maui, Lāna'i, Moloka'i, and Kaho'olawe) and Penguin Bank (Hudnall 1978, Baker and Herman 1981, Mobley and Bauer 1991). Though typically reported between November and May (Glockner and Venus 1983), the peak abundance of humpbacks occurs approximately between mid-February and mid-March (Baker and Herman 1981).

Humpback whales come to Hawaiian

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[2] Hawai'i Institute of Marine Biology, P.O. Box 1346, University of Hawai'i, Kāne'ohe, Hawai'i 96744.

[3] National Marine Fisheries Service, Pacific Area Office, 2570 Dole Street, Honolulu, Hawai'i 96822-2396.

[4] For reprints and correspondence.

waters for reproductive activity, which includes rearing calves and breeding (Chittleborough 1965, Herman and Antinoja 1977, Mobley and Herman 1985, Baker et al. 1986). Newborn and nursing calves with cows are seen throughout the winter months in Hawai'i and appear preferentially to use leeward, nearshore waters within the 10-fathom (18 m) isobath, especially along the north coast of Lāna'i (Forestell 1986), Mā'alaea Bay on Maui (Hudnall 1978), and the west Maui area (Glockner and Venus 1983).

Estimated body length may be used to infer age. In one case a female calf killed under special license, in the company of a lactating female and still suckling, was estimated to be approximately 10.5 months of age from a measurement of 8.76 m in length (Chittleborough 1959). Most humpbacks reach puberty at a mean age of 4 or 5 yr (Chittleborough 1959, 1960, 1965, Nishiwaki 1959, Slijper 1962, Clapham 1992, 1994) and have a body length greater than 11.6 m for males and 12.0 m for females (Matthews 1937, Nishiwaki 1959, Rice 1963).

The purpose of the study reported here was to perform an archival analysis of deaths and entanglements of humpback whales in Hawaiian waters. We present information on body length, annual frequency, location, and seasonal distribution of deaths and entanglements in the main Hawaiian Islands. From the body lengths and notes of documented reports, we estimated age classes (calf, juvenile, and adult) for the dead and entangled whales.

MATERIALS AND METHODS

This study covered the period from 1972 through October 1996 and investigated the coastal areas of the main Hawaiian Islands extending from Kaua'i (22°20′ N, 159°80′ W) to the island of Hawai'i (19°30′ N, 155°30′ W). In addition, one other case (1936) is reported here, but was not included in the data analysis. Data concerning the deaths and entanglements were obtained from the National Marine Fisheries Service, Pacific Area Office. This information was confirmed and augmented by comparison with data from stranding-response personnel involved with the Marine Mammal Stranding Network of Hawai'i and with data published in local newspaper reports.

Data on the death and/or entanglement event, month of event (considered to be the same as the date reported in Table 1), location, gender (if known), body length, and estimated age class were documented. To estimate the age class, body length and field notes documented from humpbacks in Hawaiian waters were used in addition to published parameters taken from whale catch data (Matthews 1937, Chittleborough 1959, 1960, 1965, Nishiwaki 1959, Slijper 1962, Rice 1963, Clapham 1992, 1994). Animals less than 8.0 m long were defined as "calf" and presumed to be a calf of the year (Chittleborough 1959, Nishiwaki 1959, Rice 1963, Nitta 1991, Silvers et al. 1997). Humpbacks measuring between 8.0 and 11.6 m long were defined as "juvenile" and considered to be 1–5 yr old, including yearlings and semi-independent animals (Nishiwaki 1959, Rice 1963, Clapham 1992, 1994). Based upon the average length of sexual maturity of this species, animals measuring greater than 11.6 m in length were defined as "adult" and considered to be approximately 5 yr and older and sexually mature (Nishiwaki 1959, Rice 1963, Clapham 1992, 1994).

RESULTS

A total of 26 deaths and entanglements of humpback whales was recorded between 1972 and October 1996. There were two reports with exact dates unconfirmed during 1972 and 1990, and one additional record from 1936 (Table 1). The additional record (14 March 1936) was not included in the analyses (Figures 1–7) because stranding data were poorly kept before the early 1970s. Years not listed indicate that no deaths or entanglements of humpback whales were reported.

The number of deaths and entanglements per year was analyzed using chi-square analysis to see if there was a significant depar-

TABLE 1

DEATHS AND ENTANGLEMENTS OF HUMPBACK WHALES, *Megaptera novaeangliae*, IN THE MAIN HAWAIIAN ISLANDS FROM 1972 TO OCTOBER 1996, AND AN ADDITIONAL REPORT FROM 1936 (EXACT DATES OF THE 1972 AND 1990 REPORTS ARE UNCONFIRMED; AGE CLASS AND CAUSE OF DEATH WERE TAKEN FROM FILE NOTES AND NEWS REPORTS)

DAY	MONTH	YEAR	ISLAND	GENDER	LENGTH (m)	AGE CLASS	NOTES AND STATUS OF WHALE
14	Mar.	36	O'ahu	?	5.47	Calf	Found stranded alive. Spectators hauled it ashore where it died and was eventually discarded.
?	?	72	Hawai'i	?	?	Calf	Whale watch vessels observed a calf attacked and eaten alive by four to five false killer whales, *Pseudorca crassidens*. The calf's mother appeared to be trying to prevent the final outcome and was agitated during and after the attack.
18	Feb.	73	O'ahu	?	?	Calf	Found dead, stranded. Cause of death unknown.
?	Feb.	75	Molokini	?	?	Calf	Found alive, physically emaciated, and abandoned by its mother. After several days it was observed being eaten alive by sharks.
11	Feb.	78	Maui	?	2.44–3.05	Calf	Reports state that two adult whales attempted to keep the newborn's head above water for hours. Possibly stillborn and subsequently abandoned by its mother, 75% of the carcass was eaten by sharks. Subsequently it beached and the remains were buried.
11	Apr.	79	Hawai'i	?	4.27	Calf	Found by whale watch organization extremely decomposed; estimated beached since mid-March; left at site.
22	Feb.	81	O'ahu	M	4.63	Calf	Found stranded alive; estimated age <2 weeks. Transported to Sea Life Park (Waimānalo, Hawai'i) and maintained for 8 days, where it died. Cause of death: complications caused by a collapsed left lung and infection leading to pneumonia of the right lung.
13	Jan.	86	Kaho'olawe	?	12.40	Adult	Found extremely decomposed; 25% of the carcass eaten by sharks; left at site.
3	Feb.	87	Kaua'i	?	4.57–4.88	Calf	Found moderately decomposed; estimated beached for several days; estimated age 1 month. Posterior 1/3 eaten by sharks; cause of death unknown.
20	Mar.	87	Moloka'i	?	4.60	Calf	Found extremely decomposed; left at site; cause of death unknown.
27	Jan.	89	Kaua'i	M	4.01	Calf	Found stranded alive; pushed back into water. Found dead the next day; estimated age 1 month. Remains buried; cause of death unknown.
?	?	90	Maui	?	6.10	Calf	Found decomposed; U.S. Coast Guard sighting.
16	Feb.	91	O'ahu	F	4.00	Calf	Found fresh dead; cause of death unknown.
23	Mar.	91	Hawai'i	F	4.75	Calf	Found decomposed; estimated beached since 17 March 1991. Remains left at site; cause of death unknown.
18	Feb.	92	Hawai'i	F	?	Adult	Sighted, videotaped, and disentangled by U.S. Coast Guard. Adult female seen with current season's calf and escort. The lactating female was tangled in a mass of netting composed of 7-mm polyester line, 1/2″ (1.3 cm) polypropylene line, standard bouys, empty bleach bottles, and large baited (ulua) hooks. During surface intervals, the calf had line across its dorsal side, but did not appear to be entangled. Except when breathing, the escort remained beneath the entangled whale during the 2-hr disentangling operation.

TABLE 1 (continued)

DEATHS AND ENTANGLEMENTS OF HUMPBACK WHALES, *Megaptera novaeangliae*, IN THE MAIN HAWAIIAN ISLANDS FROM 1972 TO OCTOBER 1996, AND AN ADDITIONAL REPORT FROM 1936 (EXACT DATES OF THE 1972 AND 1990 REPORTS ARE UNCONFIRMED; AGE CLASS AND CAUSE OF DEATH WERE TAKEN FROM FILE NOTES AND NEWS REPORTS)

DAY	MONTH	YEAR	ISLAND	GENDER	LENGTH (m)	AGE CLASS	NOTES AND STATUS OF WHALE
27	Mar.	92	Lāna'i	?	4.27	Calf	Found fresh dead with no visible scars or injury. The tide must have taken the carcass out because it was not seen the next day; cause of death unknown.
?	Jan.	93	Hawai'i	?	10	Juvenile	Sighted and underwater video footage obtained by a local research group. This whale was entangled in 1/2″ (1.3 cm) Dacron sinking line that wrapped around and then trailed from its pectoral fin and fluke. The trailing net was not visible above the water. The animal was swimming erratically and showing other signs of agitation, likely due to entanglement. The animal was able to disentangle itself; survival unknown.
1	Mar.	95	Maui	?	10.90	Juvenile	Found alive; tangled in mooring lines. The U.S. Coast Guard cut the whale free, but several lines remained attached. Two hours later the whale beached on a reef where numerous sharks attacked the whale while it was still alive. Fatally wounded by shark attacks, the whale died. Estimated age 1–3 yr; the whale was dragging six ropes from its tail, including a 120-foot (36 m) length of 1/2″ (1.3 cm) line used to moor boats. The entanglement may have caused the weakness that subsequently left the whale vulnerable to predation.
3	Apr.	96	Maui	?	?	Calf	Observed by two whale-watch catamarans, a calf was being attacked by several tiger sharks. The escort was "tail lobbing" while the mother attempted to keep the calf above her back. Eventually the calf disappeared. Survival was unlikely; calf was presumed dead.
21	Jan.	96	Maui	F	12.2–12.4	Adult	First sighted by a whale-watch vessel and subsequently observed, photographed, and videotaped at length by two local research groups. This whale was emaciated and had a thick substance, most likely whale lice, all over its body. The growth was so thick that it was reported to resemble a "carpet." During the 10–12 hr of observation, the whale did not move except to crane its head up to the surface to breathe. The whale's tail stock appeared to be dislocated laterally; vertebrae bulged beneath the skin on the opposite side but did not break the skin. After observation and analyzing the slide and film footage, the general consensus was that the whale appeared to have a broken back as a result of some sort of forceful strike, possibly a moving vessel; survival is unknown (Osmond and Kaufman 1998).

29	Jan.	96	O'ahu	?	10.67	Juvenile	Sighted and videotaped by a whale-watch vessel. The animal was tangled in "crabpot" lines, mostly around its head near the blowhole, dragging an attached buoy. The animal was surrounded by other whales that were contacting the entangled portions of the whale with their bodies, appearing to "rub off the net." The young whale appeared panicked, swimming at the surface and emitting "stress blows." The animal was tracked for 4–6 miles (6–10 km) and was last seen headed toward Kaua'i; survival is unknown.
1	Feb.	96	O'ahu	M	4.42	Calf	Found stranded alive and injured in the early afternoon. Last seen alive at nightfall with parts of the umbilicus still attached. Found dead the next day with injuries including propeller cuts on dorsal side. Cause of death appears to be the result of excessive trauma, due to propeller strike.
4	Feb.	96	Kaua'i	?	10.67	Juvenile	First sighted by a whale-watch vessel. This animal was found with 25 cookiecutter shark bites on its sides, stressed, exhausted, and with 3/8″ (1 cm) Dacron rope tightly wrapped around its tail. Also attached to the whale were several hundred feet of rope and a large tangled mass of "cargo" netting. All of this material hung up on the ocean bottom, tethering the whale to one location. Although lines were eventually cut, the whale was improperly disentangled. Rope was left wrapped around its left pectoral fin and both strands of rope were through the whale's mouth, from left to right. Both of the free ends were cut only 2–3 ft (60–90 cm) posterior to the flukes. The whale left the scene partially entangled and with rope still attached; survival is unknown.
7	Feb.	96	Hawai'i	?	10.7–12.2	Adult	First sighted on 6 February 1996 entangled in "heavy lines" with 10–12 large tiger sharks nearby. Found the following day, obviously exhausted, 250 yds (230 m) offshore with numerous tight wraps of 1/2″ (1.3 cm) diameter synthetic line wrapped around its tail. The whale was effectively hog-tied because the lines ran forward along each side of the whale and wrapped around each pectoral fin. The other end of the line trailed to the ocean bottom where the line was apparently caught on the bottom, prohibiting any ability to swim, but with enough scope to allow breathing. Two 8–10 ft (2–3 m) tiger sharks circled the whale during a 2-hr rescue effort in which the whale was disentangled. The whale was last seen slowly swimming away; survival is unknown.
9	Feb.	96	Maui	M	12.20	Adult	Research vessels reported four males and one female engaging in mating/courtship activity during the afternoon hours. Subsequently, one male floated motionless (after an hour of not breathing it was determined to be dead) being "guarded" by another male. This continued for hours and into the night. Death appeared to be the result of a competitive battle.
13	Feb.	96	Maui	?	?	Adult	Found floating with thoracic cavity opened by sharks, with sharks still feeding on the carcass.
?	Feb.	96	Hawai'i	?	?	Adult	A humpback whale caught in line and dragging attached bouy was sighted from a shore station by theodolite operator. The whale disappeared to the north. No attempt to follow or disentangle the whale was made because the seas were rough; survival is unknown.

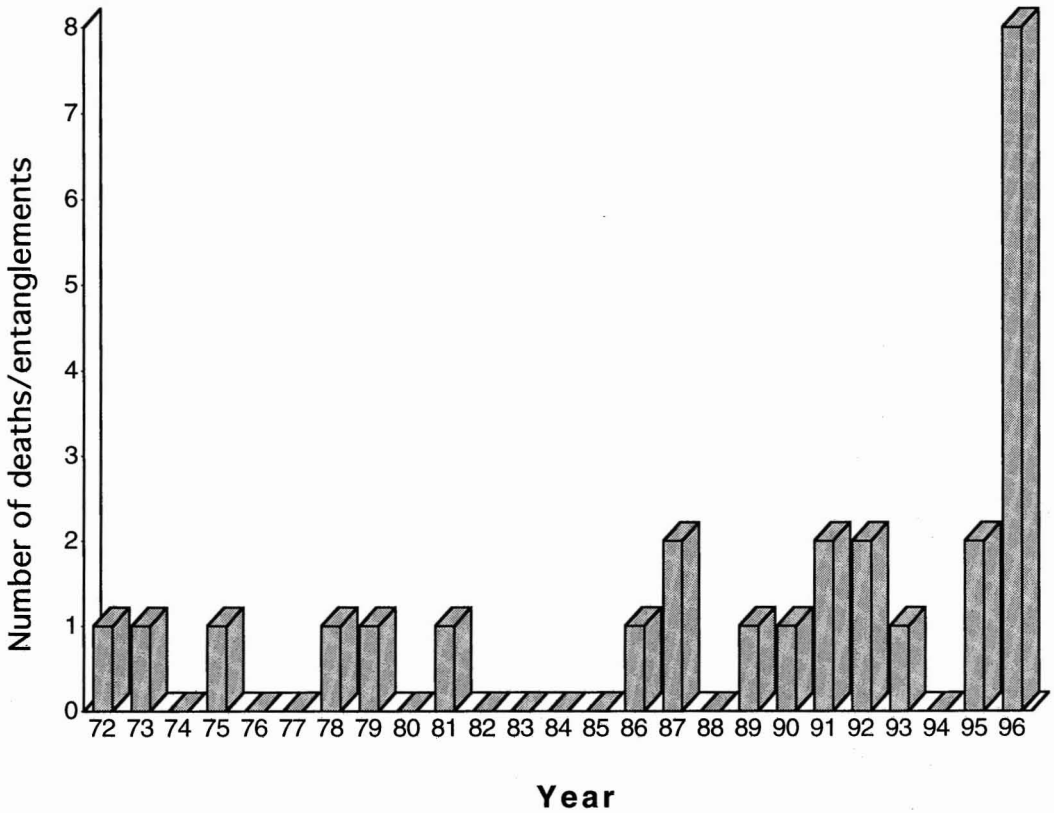

FIGURE 1. Number of humpback whales dead or entangled over a 25-yr period in the main Hawaiian Islands from 1972 through October 1996. An additional whale was reported in 1936. The exact dates of the 1972 and 1990 reports are unconfirmed. No deaths or entanglements were reported from 1937 to 1972.

ture from expected frequency. The period from 1972 to 1996 was divided into 5-yr intervals. Differences in number of events across the resulting five intervals were significant ($X^2 = 10.8$, df $= 4$, $P < 0.05$), with the more recent period (1993–1996) showing the greatest departure from expected frequency ($n = 11$ cases [Figure 1]). Although there was a 5-yr period of no reported deaths and/or entanglements between 1981 and 1986, the annual frequency of occurrence over the 25-yr period indicates an increasing trend of entanglement in natural fiber and synthetic lines since 1992. Although unevenly dispersed over this 25-yr period (Figure 1), there was a mean of one humpback whale death or entanglement reported every year in the main Hawaiian Islands.

Each of the main Hawaiian Islands recorded at least one death or entanglement, although various numbers were reported per island (Figure 2). The greatest incidence of deaths and entanglements occurred off Hawai'i and Maui (27% each) and O'ahu (19%). When reports were combined, the three islands accounted for nearly 75% of all reported deaths and entanglements. Deaths and entanglements reported off Kaua'i accounted for 11% of the total, and occurrence was evenly dispersed off Moloka'i, Lāna'i, Kaho'olawe, and Molokini, respectively. Deaths and entanglements were more frequent off the leeward coasts of the islands, with two-thirds of whale deaths and entanglements occurring off leeward coasts and one-third off windward coasts (Figure 3).

Deaths and entanglements occurred with the greatest frequency in February (54%),

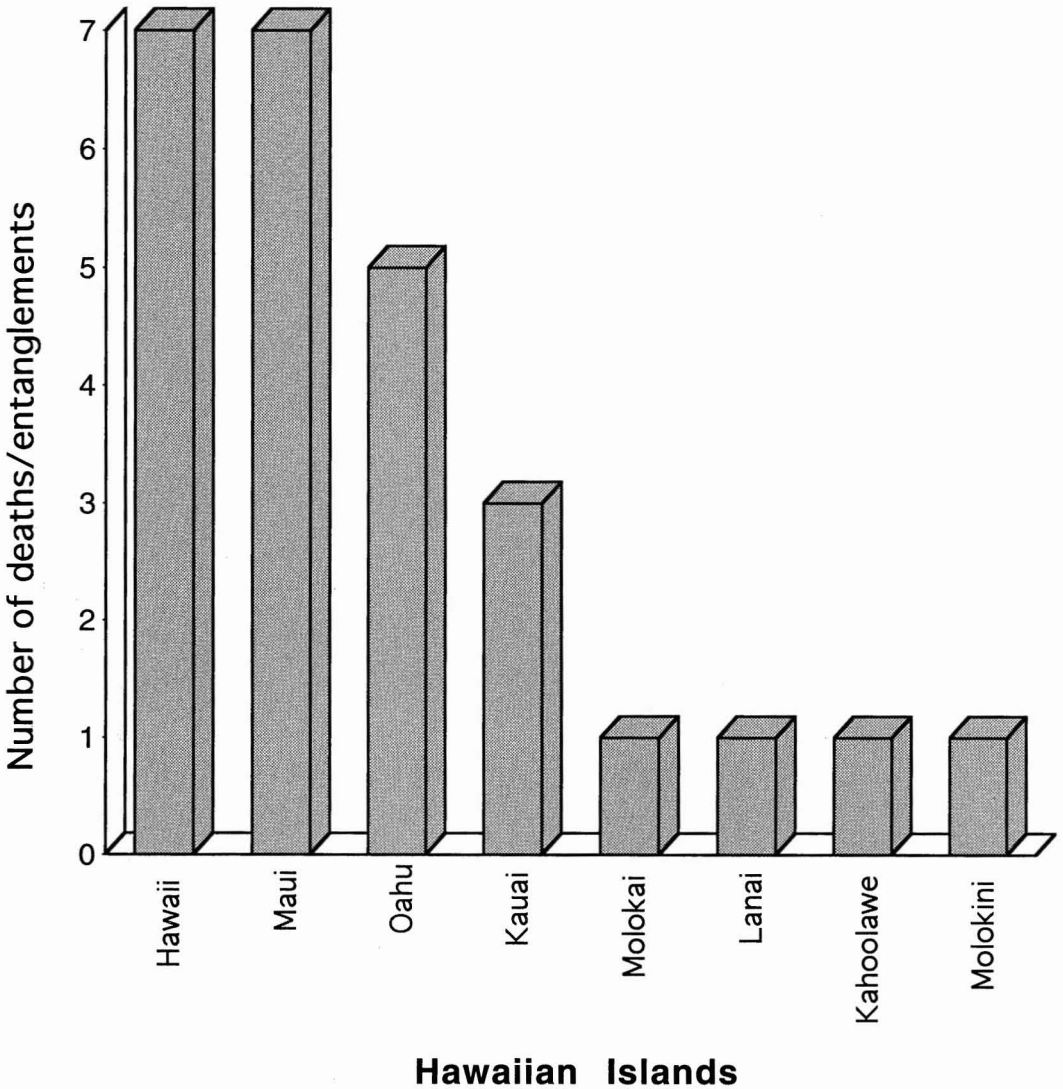

FIGURE 2. Number of deaths and entanglements of humpback whales, per island, in the Hawaiian Islands from 1972 through October 1996.

followed by March (19%), and January (15%) (Figure 4). With the exception of the two events with unconfirmed dates (1972 and 1990), the months of January, February, March, and April account for all of the deaths and entanglements.

Data on body length and/or corresponding notes on file were available for all of the animals (Figure 5, Table 1). Where body length was not recorded ($n = 7$), documented report notes were used to infer age class. Body length indicated that over half of the dead or entangled whales were less than 8.0 m long and hence designated as calves (Figure 5). Based on the reported body length, 58% were calves of the year, 19% were juveniles, and 23% were adults (Figure 5). Information on gender was available for eight of the 26 whales. Fifty percent (4/8) were male and 50% (4/8) were female.

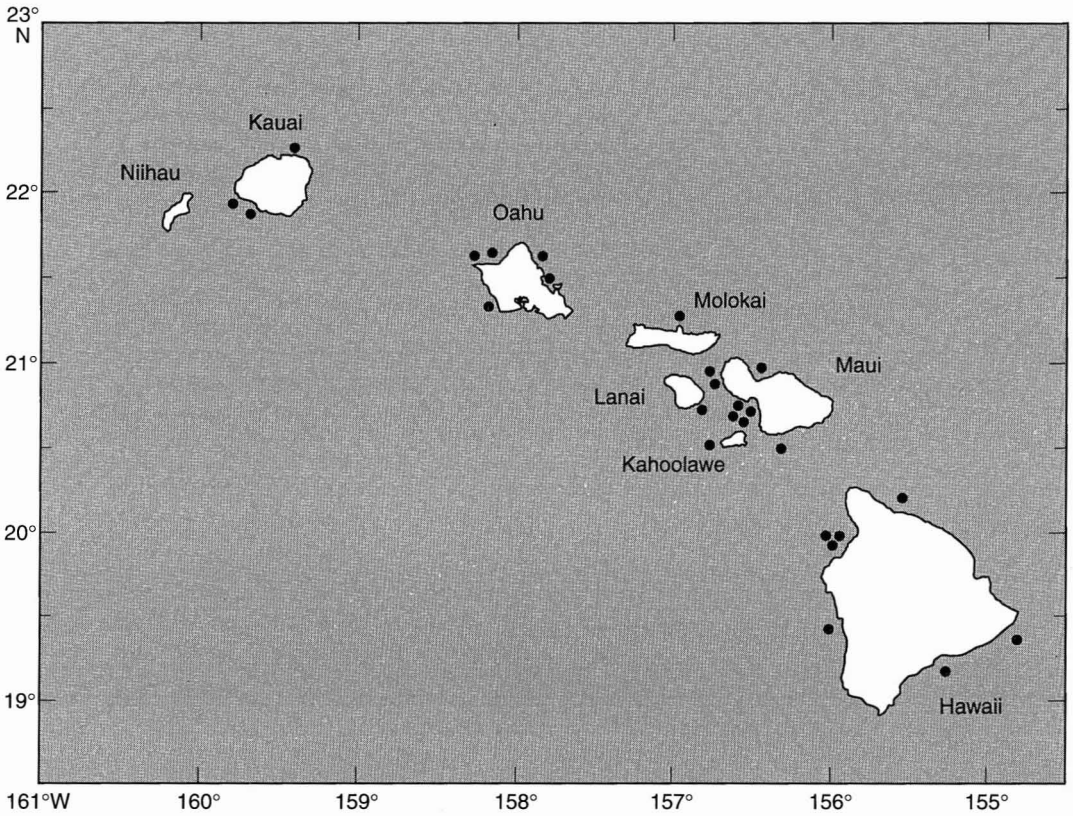

FIGURE 3. Map of the Hawaiian Islands with solid dots indicating the locations of the reported death or entanglement of humpback whales from 1972 through October 1996.

Of the 26 reported cases, seven were entanglements, of which one died as a result of shark predation and six had unknown outcomes. The entangled whales with unknown outcomes were disentangled or partially disentangled with human intervention, or not disentangled (Figure 6). The cause of death for the majority of whales was unknown; however, in some cases with known causes of death, shark attacks, vessel strike, illness (confirmed by necropsy), and aggression by conspecifics were noted.

DISCUSSION

The results of this study indicate that deaths and entanglements of humpback whales in the main Hawaiian Islands were predominantly of calves of the year, with the age class determined either from notes in the reports or from body length. This may not seem surprising because every species experiences some perinatal hazards in the environment, and calves may not have the immunocompetence, strength, or endurance of older whales. However, the proportion of the total number of reported cases of humpback whales that either died or were entangled is remarkedly skewed toward calves when compared with other cetacean species (National Marine Fisheries Service, unpubl. data), indicating that this portion of the population should be an area of focus in the management of North Pacific humpback whales. Information on calf mortality is a critical parameter for determining recruitment rates. Calf and juvenile survival is

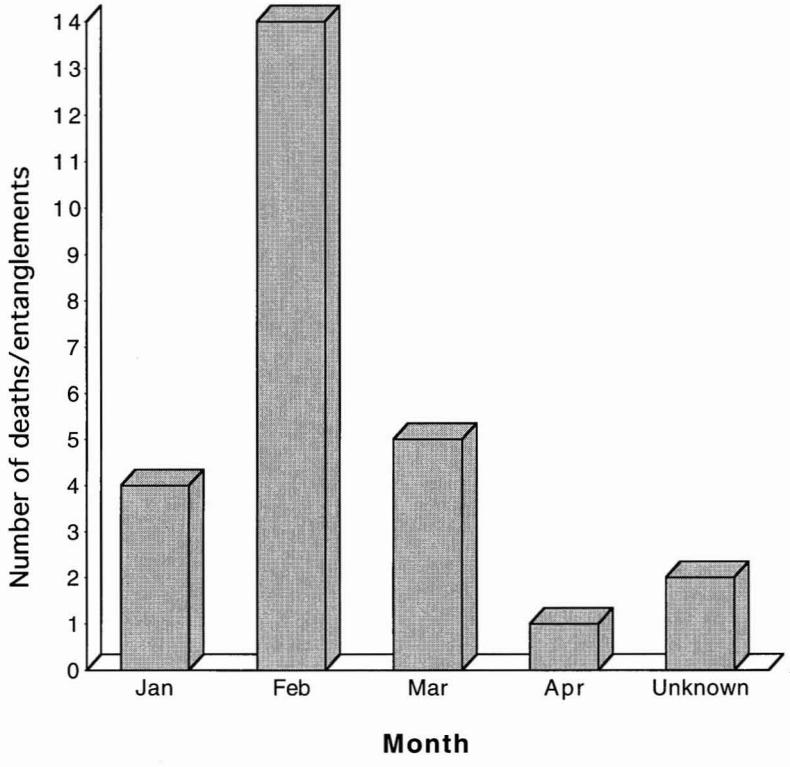

FIGURE 4. Number of deaths and entanglements of humpback whales per month in the main Hawaiian Islands from 1972 through October 1996.

one of the most important components of recruitment to the reproductive portion of the population, and its quantification is essential to assess the rate of recovery of an endangered species. Although recent aerial surveys suggest an increase in the overall humpback population wintering in Hawai'i (Mobley and Bauer 1991), the rate of neonatal mortality of humpback whales in the North Pacific has not been quantified and continues to be of concern in the recovery of this endangered species.

The cause of death in many of the reported cases was not determined with certainty. Because most cases were inferred by observation, not from thorough necropsy, cause of death could not be examined thoroughly in this paper. Several reports concluded that fatal shark attacks were the final cause of death. Without the carcass for thorough necropsy, however, the primary agent that predisposed the whale to shark attack could not be determined. In entanglements, it may be that the animal was stressed and subsequently weakened from being caught in debris, lessening its strength and defense against natural predators such as sharks. Complete necropsies of the animals, when possible, would allow a more reliable investigation into the causes of mortality and provide a greater ability to evaluate the status of this population.

The highest frequency of deaths and entanglements occurred off the islands having the largest human populations: O'ahu, Maui, and Hawai'i (State of Hawai'i 1995). This may be due to increased effort and a potentially higher incidence of being sighted and reported. However, the number of incidents appears to be in proportion to the relative densities of humpback whales around the main Hawaiian Islands (Mobley et al. 1994),

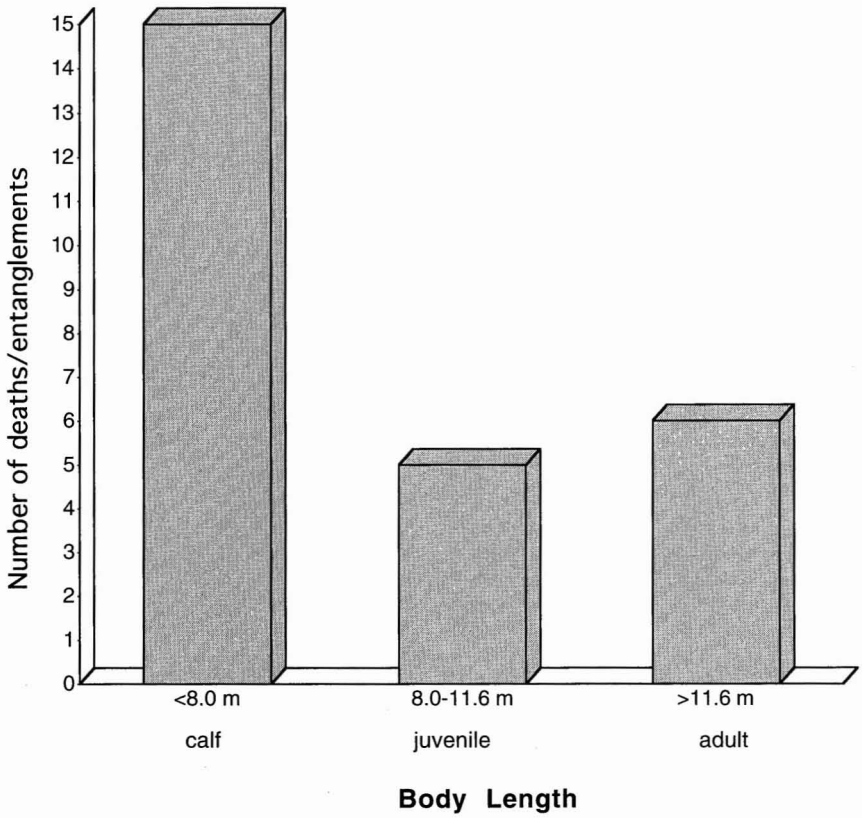

FIGURE 5. Reported body length for each humpback whale reported dead or entangled in the Hawaiian Islands from 1972 through October 1996. Whales less than 8.0 m long were classified as calves, those 8.0–11.6 m long as juveniles, and those greater than 11.6 m long as adults. Length of whales was not reported in 1973 and 1975, but age estimates were recorded. Both were calves of the year.

with most of the deaths and entanglements occurring in the four-island region (Maui, Moloka'i, Lāna'i, and Kaho'olawe) where the greatest densities of whales are typically found. The frequency of deaths and entanglements was apparently unaffected by the trade winds around the Islands because more than two-thirds of the reports were from off the leeward sides of the Islands.

The annual frequency of deaths and entanglements over the past 25 yr rose sharply in 1996. No entanglements occurred before 1992, whereas 60% of reports in subsequent years involved entanglements in natural fiber and synthetic lines. These entanglements were caused by lines restricting mobility, thereby immobilizing or nearly immobilizing the whale in four of seven entanglement cases. The increase in the number of entanglements reported may again be due to differential effort between years, possible increase in population, change in distribution, or an increase in human activity, but may also indicate the start of a potential trend that should be the focus of future management plans. Notably, all but two of the deaths and entanglements reported in 1995 and 1996 were related to human activity, including a direct strike, possibly two, from a moving vessel. These results supplement data on entrapment and entanglement in active fishing gear, which is a frequently identified source of human-caused injury or mortality to humpbacks and other large whales in areas such as the northeastern

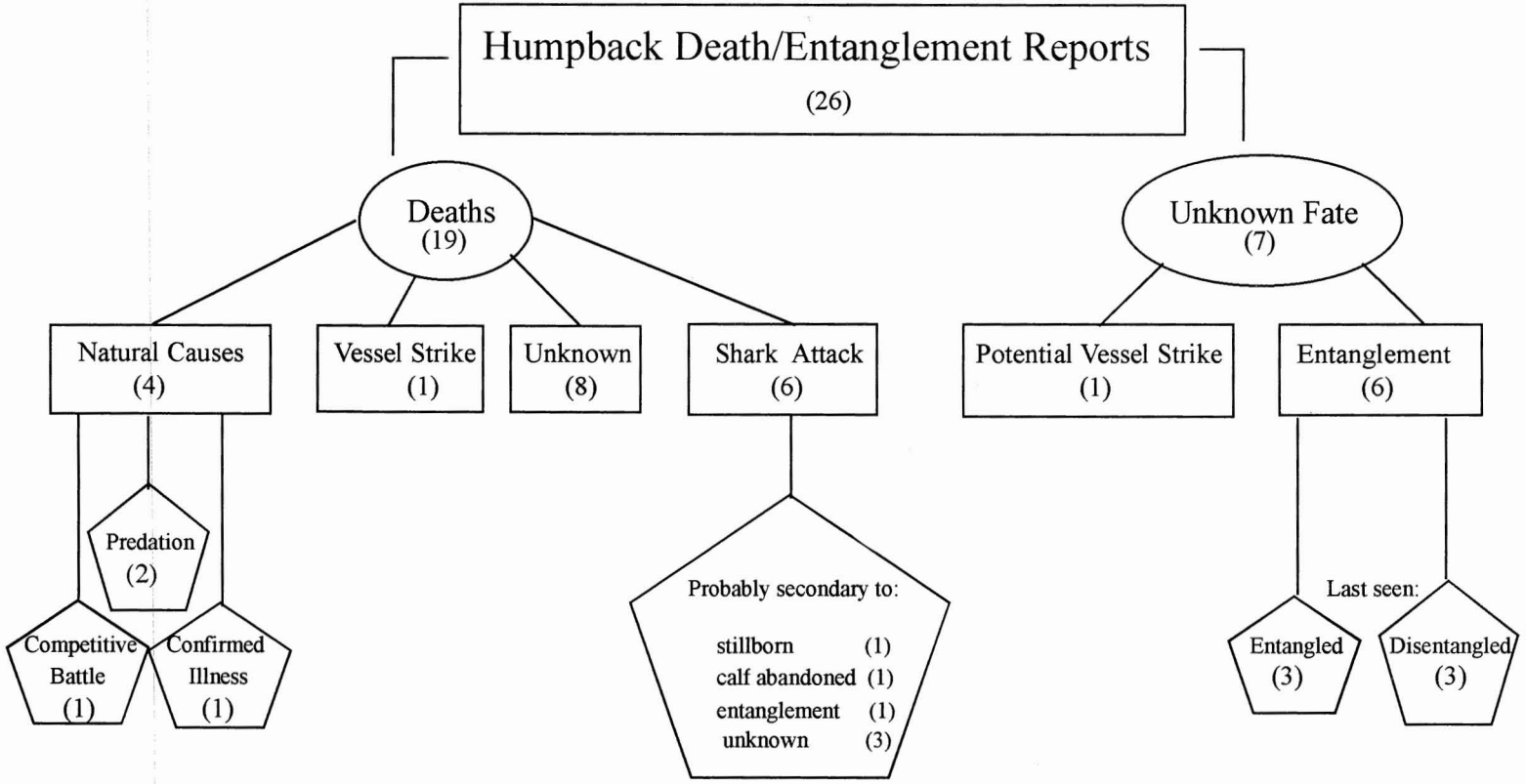

FIGURE 6. Breakdown of humpback deaths and entanglements from 1972 through October 1996. The flow chart shows the number and causes of deaths (left side) and unknown outcomes (right side).

United States and Newfoundland (O'Hara et al. 1986, Lien et al. 1989).

The seasonal distribution of humpback whale deaths and entanglements was restricted to the four primary months of the Hawaiian wintering period (January–April). By far, the primary month of occurrence was February, when densities of humpback whales reach peak levels (Baker and Herman 1981). Increased public education and awareness of the effects of human activities may serve to reduce interactions that may result in mortality or decreased survival of humpback whales during this critical month.

Data contained in this paper reinforce the importance of the habitat for humpback whales, especially lactating females and their newborn calves. Proper monitoring and management of this endangered population in its breeding grounds around the state of Hawai'i is essential. Future research directed at determining causes of death or the effects of any human or human-related activity that may adversely affect the whales, especially the survival of calves, would benefit the recovery of the population.

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